

IN THE CLAIMS:

The following listing of claims will replace all prior versions, and listings, of the claims in the application:

- 1-42. (Canceled)
43. A hydrogen storage system, comprising:  
a storage material comprising a plurality of non-planar nanostructures formed of at least one light element, wherein the plurality of non-planar nanostructures are selected from the group consisting of nanoplatelets, nanocages, nanococoons, nanotorii, nanotubes, nanofibers, nanorods, nanowires, buckyballs, nanocoils, and nanohorns, the at least one light element is selected from the group consisting of Be, B, C, N, O, F, Mg, P, S, and Cl, and the storage material is characterized by a binding energy to adsorbed hydrogen substantially greater than 0.10 eV; and  
hydrogen adsorbed by the storage material.
44. The hydrogen storage system of Claim 43, wherein the storage material is characterized by a hydrogen desorption temperature greater than about 60 K.
45. The hydrogen storage system of Claim 43, wherein the plurality of non-planar nanostructures are selected from the group consisting of thin nanoplatelets, thick nanoplatelets, and intercalated nanoplatelets.
46. The hydrogen storage system of Claim 43, wherein the plurality of non-planar nanostructures comprise nanotubes.
47. The hydrogen storage system of Claim 43, wherein the plurality of non-planar nanostructures consist essentially of nanotubes.

48. A hydrogen storage system, comprising:

a storage material comprising a plurality of nanostructures formed of a combination of at least two light elements, wherein the plurality of nanostructures are selected from the group consisting of nanoplatelets, nanocages, nanococoons, nanotorii, nanotubes, buckyballs, nanocoils, and nanohorns, the at least two light elements are selected from the group consisting of Be, B, C, N, O, F, Mg, P, S, and Cl, and the plurality of nanostructures each comprise a non-equilateral triangular lattice configured such that the storage material has a binding energy to adsorbed hydrogen substantially greater than 0.10 eV; and

hydrogen adsorbed by the storage material.

49. The hydrogen storage system of Claim 48, wherein the storage material is characterized by a hydrogen desorption temperature greater than about 60 K.

50. The hydrogen storage system of Claim 48, wherein the at least two light elements consist of a compound of B and N.

51. The hydrogen storage system of Claim 48, wherein the at least two light elements consist of a compound of C and N.

52. The hydrogen storage system of Claim 48, wherein the at least two light elements consist of a compound of B, C, and N.

53. The hydrogen storage system of Claim 48, wherein the at least two light elements consist of a compound of Mg and B.

54. The hydrogen storage system of Claim 48, wherein the at least two light elements consist of a compound of B and O.

55. A hydrogen storage system, comprising:

a storage material comprising a plurality of nanostructures formed of at least one light element, wherein the plurality of nanostructures are selected from the group consisting of nanoplatelets, nanocages, nanococoons, nanotorii, nanotubes, buckyballs, nanocoils, and nanohorns, the at least one light element is selected from the group consisting of Be, B, C, N, O, F, Mg, P, S, and Cl, and the plurality of nanostructures are configured with a plurality of lattice defects such that the storage material has a binding energy to adsorbed hydrogen substantially greater than 0.10 eV; and

hydrogen adsorbed by the storage material.

56. The hydrogen storage system of Claim 55, wherein the storage material is characterized by a hydrogen desorption temperature greater than about 60 K.

57. The hydrogen storage system of Claim 55, wherein the plurality of lattice defects include a substantial number of defects characterized by a light element of a first kind implanted into a molecular lattice formed by a light element of a second kind.

58. The hydrogen storage system of Claim 55, wherein the plurality of lattice defects include a substantial number of defects characterized by a light element of a first kind implanted into a molecular lattice formed by light elements of second and third kinds.

59. The hydrogen storage system of Claim 55, wherein the plurality of lattice defects include a substantial number of defects characterized by hydrogen atoms coupled to a molecular lattice in place of atoms of the at least one light element that are removed from the lattice.

60. The hydrogen storage system of Claim 55, wherein the plurality of lattice defects include a substantial number of defects characterized by a plurality of molecular lattice pentagons coupled to a plurality of molecular lattice heptagons.

61. The hydrogen storage system of Claim 60, wherein the plurality of molecular lattice pentagons and the plurality of molecular lattice heptagons are coupled in 5 – 7 neighbor pairs in the plurality of nanostructures.

62. The hydrogen storage system of Claim 55, wherein the plurality of lattice defects include a substantial number of defects characterized by an electron donor atom coupled to a molecular lattice of the plurality of nanostructures.

63. The hydrogen storage system of Claim 55, wherein the plurality of lattice defects include a substantial number of defects characterized by an electron acceptor atom coupled to a molecular lattice of the plurality of nanostructures.

64. A method of making a hydrogen storage system, comprising:  
forming a storage material comprising a plurality of nanostructures of at least one light element, wherein the plurality of nanostructures are selected from the group consisting of nanoplatelets, nanocages, nanococoons, nanotorii, nanotubes, nanofibers, nanorods, nanowires, buckyballs, nanocoils, and nanohorns, the at least one light element is selected from the group consisting of Be, B, C, N, O, F, Mg, P, S, and Cl, and the storage material is characterized by a binding energy to adsorbed hydrogen substantially greater than 0.10 eV; and  
adsorbing hydrogen using the storage material.

65. The method of Claim 64, wherein the adsorbing step is performed below a desorption temperature, wherein the desorption temperature is greater than 60 K.

66. The method of Claim 64, wherein the forming step further comprises forming the storage material by combining at least two light elements selected from the group consisting of Be, B, C, N, O, F, Mg, P, S, and Cl.

67. The method of Claim 64, wherein the forming step further comprises forming the storage material using a chemical vapor deposition synthesis and a flow of doping gas.

68. The method of Claim 67, wherein the forming step further comprises forming the storage material using a flow of doping gas, the doping gas selected from the group consisting of  $\text{NH}_3$ ,  $\text{CH}_3\text{NH}_2$ ,  $(\text{CH}_3)_2\text{NH}$ ,  $(\text{CH}_3)_3\text{N}$ ,  $\text{BCl}_3$ ,  $\text{BF}_3$ ,  $\text{B}_2\text{H}_6$ , a borohydride,  $\text{SiH}_4$ ,  $\text{Si}_2\text{H}_6$ ,  $\text{SiCl}_4$ ,  $\text{SiF}_4$ ,  $\text{SiH}_2\text{Cl}_2$ ,  $\text{H}_2\text{S}$  and  $\text{PH}_3$ .

69. The method of Claim 66, wherein the forming step further comprises forming the storage material by forming a graphite powder and the at least two light elements into an electrode, and then using the electrode to arc synthesize the plurality of nanostructures.

70. The method of Claim 64, wherein the forming step further comprises forming the storage material by ball milling the plurality of nanostructures with a powdered dopant.

71. The method of Claim 64, wherein the forming step further comprises forming the storage material comprising a plurality of nanostructures having a non-planar shape.

72. The method of Claim 64, wherein the forming step further comprises forming the storage material comprising a plurality of nanostructures having a substantial portion of molecular lattice defects.

73. The method of Claim 72, wherein the forming step further comprises forming the storage material by exposing the plurality of nanostructures to a flow of ozone, and then annealing the plurality of nanostructures by maintaining a temperature between about 400° C and about 1800° C.

74. The method of Claim 73, wherein the annealing step comprises annealing in one of a vacuum, a neutral atmosphere, and a hydrogen-containing atmosphere.

75. The method of Claim 72, wherein the forming step further comprises forming the storage material by removing atoms of the at least one light element from the plurality of nanostructures by a method selected from irradiation with electrons, irradiation with neutrons, irradiation with ions, irradiation with gamma rays, irradiation with X-rays and irradiation with microwaves.

76. The method of Claim 72, wherein the forming step further comprises forming the storage material by nucleating 5-7 pair defects in the plurality of nanostructures by introducing at least one of cyclopentadiene, cycloheptatriene and azulene into a flow of a chemical vapor deposition process.

77. The method of Claim 72, wherein the forming step further comprises forming the storage material by providing a charge transfer material in proximity to the plurality of nanostructures, and wherein the charge transfer material is selected from an electron donor and an electron acceptor.